is practically unweighable. This substance, which must be considered a secretion of the bacillus, possesses a characteristic physiological action in that it produces the characteristic convulsions of the disease tetanus. It is the chief toxic agent produced by the bacillus. Kitasato once found it in the heart's blood of a patient dying of tetanus. In a number of cases of tetanus which I examined chemically I did not find this poison, although perhaps this result is not of much value, as the method I employed would possibly destroy the somewhat sensitive toxin. I found in the spleen and blood of patients dying of tetanus albumoses in fair quantity which did not possess any other action than that of producing fever; they produced no convulsions, and did not cause death. I have previously stated that in one experiment I found that the ether extract of the spleen in tetanus produced convulsions when injected intravenously in rabbits. This undoubtedly occurred, but I am not at all sure that it is of very great significance; at any rate, I could not confirm the observation, and I do not wish to lay any stress on it. It must be considered at present that the chief if not the only active poison in tetanus is the secretion of the bacillus, which, when injected into the body after a certain period produces convulsions.

With regard to the albumoses which are found in the body, in the spleen and blood of patients dying of tetanus, they are undoubtedly present, They may be in some cases the result of a mixed infection by the bacillus of tetanus and other bacteria, but they may be the result of the direct action of the tetanus bacillus or of its toxin, although the proof of this is at present wanting. I did not find that the tetanus poison had any digestive action.

Diphtheria.

The chemical processes of diphtheria closely resemble those of tetanus. There is a secretory product which is formed when the bacillus is grown in peptone broth, and which is present in the membrane of diphtheria, and probably in the tissues as well. This secretory product possesses a characteristic action on the nervous system, causing in rabbits paralysis dependent on nervous degeneration. When the bacillus is grown in a solution containing digestible proteids, it digests these with the formation of albumoses and certain by-products. These albumoses, separated in the ordinary way, have a toxic action similar to, although not so powerful as, that shown by the secretory product. They are also found in the spleen and blood of persons dying of diphtheria, and possess a similar action. What part of the toxic action of the products is to be ascribed to the albumoses themselves is perhaps a matter of debate, inasmuch as the only method by which the physiological action of the secretory product can be separated from that of the albumoses is that of heat, which also affects the action of the albumoses.

What I have called the secretory products of tetanus and diphtheria are remarkably sensitive to heat; that of tetanus, for example, is completely destroyed by raising to a temperature below 80° C.; that of diphtheria is destroyed at a temperature of 60° C., and heating to lower temperatures weakens the action of the poison or alters its effects.

It is evident that the action of the powerful secretory products of pathogenic bacteria is unlike that of crystallisable poisons. First, they produce a large effect in very small doses; secondly, this effect does not always come on immediately after injection even into the venous system, but is preceded by a period during which no apparent change is occurring in the body; thirdly, the poisons are frequently selective in their action, affecting mainly the nervous system, on which they produce a profound effect. They may also disorganise the general nutrition of the body. Fourthly, they are very sensitive to heat and external conditions. Their injection into the body—their effect being preceded by a period of incubation—reproduces the action of the bacillus itself, so that one has to do with a poison which, although not living, produces a progressive change in the tissues of the body like the bacillus.

Dr. Robert Rieder, Extraordinary Professor of Surgery in the University of Bonn, has accepted an invitation from the Turkish Government to occupy the chair of surgery in the Military Medical Academy of Constantinople.

TWO LECTURES
ON
THE TEMPLES AND RITUAL OF ASKLEPIOS AT EPIDAURUS AND ATHENS.

Delivered at the Royal Institution of Great Britain

By RICHARD CATON, M.D., F.R.C.P.

Lecture II.

To-day we pass on to consider the ritual of the Asklepian shrines and the accommodation and treatment of the sick who frequented them.

It is convenient, first, to consider the Hierarchy. This consisted of the Hiereus or Hierophant, the priest, who was the head official. He was appointed annually, and he appears to have been frequently re-elected. From the Athenian inscriptions we know that sometimes he was a physician, sometimes not; so also it was with the subordinate officials. The priest was the general administrator, and had a share in the financial government of the temple. The Dadouchoi, or torch-bearers were probably subordinate priests; the Pyrophoroi, or fire carriers, among other functions. lighted the sacred fire on the altars; the Nakoroi or Zakoroi, whose duties in the temple are doubtful, but who sometimes were physicians; the Kleidouchoi, or key-bearers, who perhaps were originally a class of superior door porters, but who appear later to have assumed priestly functions; the Hieromnemones seem to have had purely secular functions, and in common with the Hiereus had charge of all receipts and payments; all were under the rule of the Boule of Epidaurus. The Kaniphoroi (or basket-bearers), and the Arrephoroi (or carriers of mysteries or holy things) were priestesses; perhaps in some measure they acted as nurses. There was als a special religious society termed the Asklepiastes.

Turning now from the priests to the suppliants. These we find came from all parts of the Greek world, and from what ancient writers tell us their numbers were great. Where were they housed? Some, of course, dwelt in the abaton, the women probably in one part, and the men in another, but as I have already pointed out, not more than 120 could find beds there at a time; perhaps the invalid was only housed there at first, and when he began to improve was drafted off to a hostel. Assuming that all the buildings which I have suggested to be hostels were such, they could not accommodate more than some four or five hundred patients. Perhaps the usual number attending may have been only some five or six hundred, while at the great festivals many thousands assembled. Whether this large number were lodged in tents or temporary wooden buildings is uncertain.

The patient on arriving probably had an interview with the priest or other official, and arranged about his accommodation with one of the Hieromnemones, or other secular person. He performs certain rites, bathes in the sacred fountain, and offers sacrifices under the direction of the Pyrophorus; the poor man gives his cake, the rich his sheep, or pig, or goat. When night comes he brings his bed clothing into the abaton and reposes on his pallet, putting usually some small gift on the table or altar. The Nakoroi having come round to light the sacred lamps, the priest enters and recites evening prayers to the god, entreating divine help and divine enlightenment for all the sick assembled there; he then collects the gifts which had been deposited on altars and tables; later the Nakoroi enter, put out the lights, enjoin silence, and command everyone to fall asleep and to hope for guiding visions from the god. The abaton was a lofty and airy sleeping chamber, its southern side being an open colonnade. It is singularly like the "shelter balcony" or "*Liegehalle*" now used in treating phthisis. According to the inscriptions the god frequently appeared in person, or in visions, speaking to the sick man or woman concerning their ailments. Whether these visitations were merely hallucinations in individuals whose imagination had been excited, or whether some priest in the dim light enacted the part of Asklepios; whether the patient was put under the influence of opium or some other drug provocative of dreams, or whether, by some acoustic trick, the priests caused the sick to hear spoken

words which they attributed to the deity, it is difficult now to say.

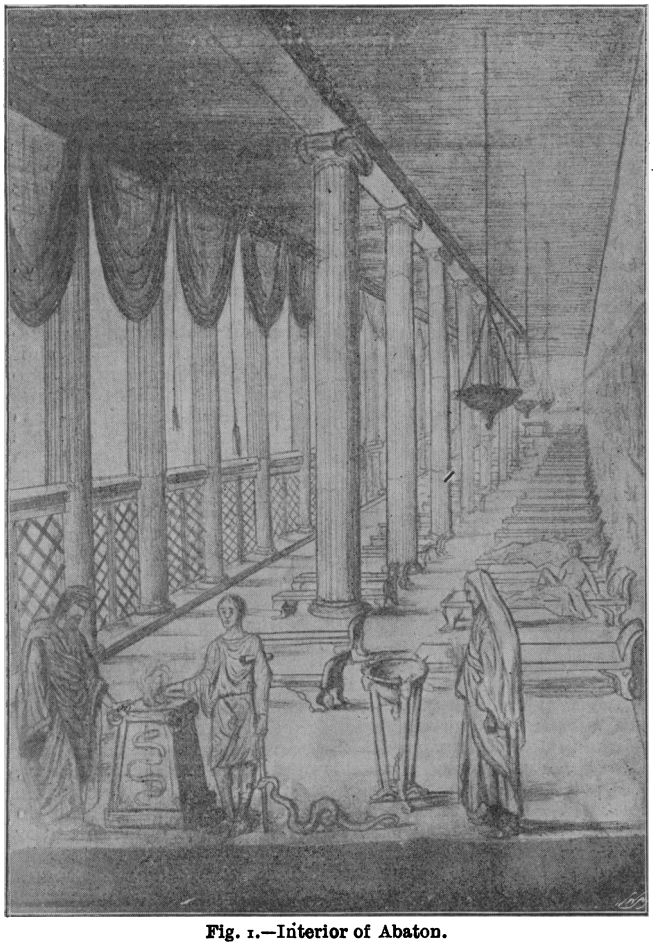

Fig. 1.—Interior of Abaton.

In the accompanying sketch of the abaton a miracle is in progress in the foreground. A lame man comes to the altar, he offers his sacrifice, the Pyrophorus lights the sacred flame, the Dadouchos or Nakoros enjoins silence while the holy serpent licks the affected part. The abaton is nearly empty as it is the day time, but one or two bedridden patients watch the miracle with interest. The valley of the Hieron was the *habitat* of a large yellow serpent, perfectly harmless, and susceptible like most snakes of domestication. I am afraid it is now extinct, though it has been seen during the present century. A number of these creatures dwelt in the sanctuary, perhaps in the vaults of the tholos. They were reverenced as the incarnation of the god. The sick were delighted and encouraged when one of these creatures approached them. The serpents seem to have been trained to lick with their forked tongue any ailing part. The dog also was sacred to Asklepios, and the temple dogs in like manner were trained to lick any injured or painful region of the body.

Many of the *malades imaginaires* who to this day are the support of the quack and the torment of the honest physician, doubtless visited Epidaurus. The priest would take such a person (as probably he took all suppliants) into the temple, and cause him to present himself before the image of the god; prayers, sacrifices, and rites of an impressive kind were then enacted. The man was caused to lay his hand solemnly and reverently on the altar, and then on the part affected; if there was really nothing the matter, he was proclaimed to be miraculously cured by the god, and doubtless his imagination was so impressed that he often himself believed in the cure.

The patients spent the day in rest or exercise, as was most agreeable to them. It must be remembered that the precinct was as beautiful as the noblest works of Greek art could make it; moreover, large and lofty trees formed a shady grove, protecting from the sun heat, while the soft breezes and the sweet pure air of the mountains formed in themselves a potent agency for the restoration of health. The patient had much around him to please and interest—beautiful buildings, rich with sculpture and with colour, scores of statuary figures and groups representing Asklepios and other divinities or subjects from the old Greek mythology in marble and

Fig. 2.—Asklepios.

bronze, reliefs, busts, and full-length figures of noted priests and physicians, ex-votos, stelæ, and tablets recording the marvellous cures effected by the god, coloured bas-reliefs, encaustic paintings, shrines, exedræ, decorative vases and fountains, beautified and added interest to the precinct. Sheltered seats, arranged in semicircles, of beautiful white marble, were so placed as to avoid sun or wind; they were convenient for converse, or for listening to a reader or a musician. Many shrines and chapels to subsidiary deities existed, as, for example, to Hygeia, Themis, the Egyptian Apollo, Helios, Selene, Epione (the wife of Asklepios), Zeus, Poseidon, Minerva, Hera, Demeter, the Eleusinian gods, Dikaiosunae, Telesphorus, Lato, Hypnos, and others.

Those of the sick who were not too ill would ascend the

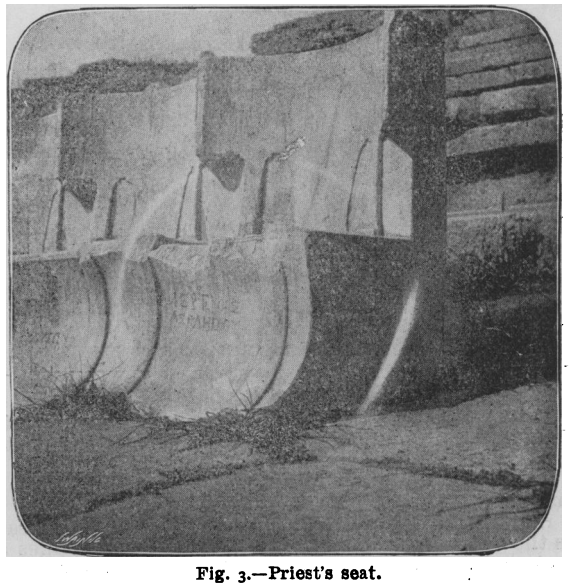

Fig. 3.—Priest's seat.

hill of Kynortion to visit the temple of Apollo, or climb the neighbouring hill of Titthion, or engage in the exercises of the gymnasium or the stadium; if unable to participate in these more active pursuits they would become spectators of them. The plays in the theatre would often make half a day pass pleasantly. We know that both priest and patient went there constantly. A photograph of the priest's seat in the Dionysiac Theatre, next to the seat of the priest of the muses is given in Fig. 3. Music, religious dances, processions, and festivals would vary the interest and occupations of the day. The studious man could occupy himself with manuscripts from the library, and, reposing in the shelter seats, would dream over history, plays, or poetry. The solemn rites of the temple, the sacrifices, the study of the multitudinous tablets, would all tend to a calm and hopeful condition of mind, eminently helpful to recovery from slight forms of illness, even though no direct medical treatment were pursued.

In the earlier times it seems as though the health-restoring influence of the shrines was thought to be wholly miraculous, with but small aid or none from art; the god alone achieved it. The more ancient inscriptions contain childishly absurd reports of miraculous cures. The ruling idea was that the deity appeared to the sick man in the abaton, applied some medicament, performed some operation, or instructed the dreaming patient to perform some act when he awoke. The frauds of the god or his priest were so outrageous that some of the old Greeks must have been almost as foolish and credulous as many modern people are, who buy pills and soaps merely because the interested vendor makes town and country hideous with his lying advertisements.

Here are one or two extracts from the case book of Asklepios:

Line 72 of the first tablet in the abaton: A man who had only one eye is visited by the god in the abaton during the night. The god applies an ointment to the empty orbit. On awaking, the man finds he has two sound eyes.

Line 125: Thyson of Hermione is blind of both eyes; a temple dog licks the organs, and he immediately regains his sight.

Line 107: Hermodius of Lampsacus comes to the Hieron in a paralysed condition. As he sleeps in the abaton the god tells him to rise, to walk outside the precinct, and carry back into it the largest stone he can find. He does so, and brings in a stone so heavy that no other man can lift it, and the stone, as the inscription says, still lies before the abaton. It lies there to-day, and the visitor may yet in vain emulate the feat of Hermodius. It will be recognised in the illustration (Fig. 4) by the hole cut in it to put the hands in.

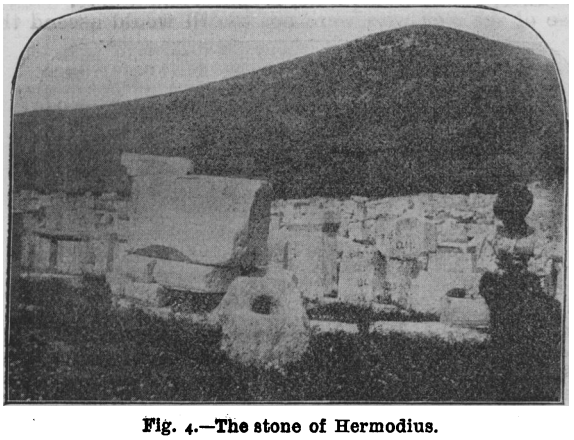

Fig. 4.—The stone of Hermodius.

Line 113: A man had his foot lacerated by the bite of a wild beast; he is in much pain, the servants of the abaton carry him outside during the daytime, as he is waiting to be healed; a serpent follows him, licks his foot, and he is at once cured.

Line 122: Heræeus of Mytilene has no hair on his head; he asks the god to make it grow again. Asklepios applies an ointment, and next morning the hair has grown thickly over his scalp (unfortunately Asklepios forgot to write down the prescription for the benefit of futurity).

At Line 48 begins a story containing a good moral. Pandarus comes all the way from Thessaly in order to have a disfiguring eruption on his forehead cured; he is quickly made well. Returning to Thessaly his cure is observed by his neighbour Echedorus, who has a similar, but slighter, eruption on the face. He also goes to Hieron, carrying with him a sum of money sent to the god by the grateful Pandarus. Echedorus decides to retain this money himself; he consults the god about his own case, and in answer to a question states that he has brought no gift from Pandarus. On rising in the morning he finds that in place of having his skin disease cured that of Pandarus has been added to it.

Line 98: A man from Toronoea is so unfortunate as to have a stepmother who is not fond of him; she introduces a number of leeches into the wine he drinks. Being of a confiding temperament he swallows them unsuspectingly, but the results are so serious that he is obliged to visit the god. Asklepios cuts open his chest with a knife, removes the leeches, sews up the chest again, and the patient returns home next day, conveying the leeches as a gift to his stepmother. Asklepios treats dropsy surgically in a heroic manner; he first cuts off the patient's head, then holds him up by the heels; the fluid all runs out. He then puts the patients head on again, and all ends happily. I think it is not necessary to repeat any more of these preposterous stories.

In later times it seems clear that superstition and deception had a less share and art a larger one in the work of healing at Hieron. Probably among the acute citizens of Athens at no period were the frauds of the god so outrageous as in the early times at Hieron. We find the priests prescribing many things that were prudent and judicious: plain and simple diet, hot and cold baths, poulticing for certain chest ailments, and a variety of medicaments, hemlock juice, helebore, squills, lime water, and drugs for the allaying of pain are incidentally mentioned. Water was used extensively both internally and externally, active gymnastic exercise, riding, friction of the skin, massage, and counter-irritation. The tablet of Apellas of Idria tells us that when visiting Hieron on account of frequent illness and severe indigestion, the god or his priests ordered a diet of bread and curdled milk, with parsley and lettuce, lemons boiled in water, also milk and honey. Apellas being an irascible person, the god ordered careful avoidance of the emotion of anger, and desired him to run, and swing in the gymnasium, and use vigorous friction and counter-irritation to the surface of the body. Probably Apellas was a wealthy and luxurious city dweller, who took too much food and Chian wine, and who suffered, as many in that age did, from gout. He is eventually cured, and erects a tablet to show his gratitude. Here is the thanksgiving of another sufferer: "Oh! Blessed Asklepios, God of Healing, it is thanks to thy skill that Diophantes, relieved of his incurable and horrible gout, no longer moves like a crab, no longer will walk upon thorns, but has a sound foot as thou hast decreed." There can be little doubt that many of the sick benefited greatly by the rest, the pure air, the simple diet, the sources of mental interest, the baths, exercise, massage and friction, and in later days by the actual medical treatment adopted. Surgical treatment was also employed, for we find marble reliefs of surgical instruments. Not infrequently it would happen that persons with real and incurable diseases came to Hieron and got worse, notwithstanding their sacrifices and petitions to the gods. How the priests excused the impotency of their deity on these occasions we do not know; perhaps some lack of merit, purity, or sanctity in the individual may have been imputed. We know that in some cases the honour of Asklepios was saved by sending the unfortunate invalid to some distant shrine, but of course it happened that in some instances the patient died. Now, according to the religion of the Greeks, two events were considered to desecrate in the most dreadful manner any hallowed precinct—namely, birth and death: neither of these must occur within any sacred enclosure. While there was probably much kindliness, humanity, and real help for the sick at these shrines, and much actual benefit resulted, notwithstanding the superstition on which all was based, still,

in this one respect, Greek tradition and ceremonial was a cause of the most gross inhumanity. The unhappy visitant whose vital powers were finally declining was received and domiciled in the abaton, but when he failed to improve and was seen by priests and attendants to be obviously dying, instead of being tenderly nursed and soothed, he was removed from his couch, dragged across the precinct to the nearest gate, expelled, and left to die on the hillside unhelped and untended. Asklepios had rejected him, and no priest or minister of the god must defile himself by any dealings with death. One cannot but hope that the sympathy and humanity which exists naturally in the hearts of most men and of all women found some means of helping these unhappy beings, and that when death seemed probable such sufferers were conveyed to a hostel outside the precinct, and allowed to die in peace there. A like superstition existed regarding birth. Many a poor woman in the later months of pregnancy, who had been hoping for relief from some ordinary ailment, was suddenly and mercilessly expelled from the precinct just when she needed help and comfort most. Not until the time of the Antonines was any definite provision made for these two classes of sufferers. Either Antoninus Pius or Marcus Aurelius erected a home for the dying, and a sort of maternity hospital. Doubtless some of the ruins dating from the Roman period, which are at present unidentified, subserved these two purposes.

Among the hundreds of inscriptions found I have thus far only mentioned one class—namely, those referring to cures. There are, in addition, no fewer than thirteen other kinds of inscriptions. For example, the great poem of Isyllos, describing the genealogy and miracles of Asklepios, written by command of the oracle of Delphi. The Delphic Sybil had a great respect for the god of healing. On another occasion she addresses him in the following flattering terms: "O thou who art born to be the world's great joy." There are numbers of inscriptions relating to the priests, the Pyrophoroi, the Hieromnemones, or in honour of distinguished Greeks or Romans; others contain laws and judicial decrees, or refer to the contests of the stadium; others again give lengthy and minute details concerning the cost of construction of the temples. In the present notice it is useless for me to speak of the numerous votive tablets, as space will not allow me to supply reproductions of more than one of them. Note the group of suppliants, with their children, approaching the god and his attendants, who are all of heroic stature.

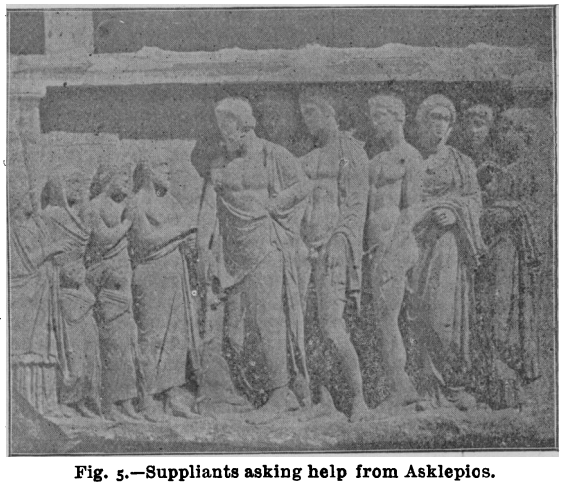

Fig. 5.—Suppliants asking help from Asklepios.

Every fourth year a great festival was held at the Hieron, the Megala Asklepieia, at which athletic contests, races, processions, music, plays in the theatre, holy vigils, lasting all night, gorgeous rites, sacrifices, decoration of the temples and precincts, together with feasts, took place. Most probably the priests would arrange for the performance of a few miracles. Other festivals were also held, as the Megala Apolloneia.

Lastly, there is a link which, though of no practical import, is still a genuine historic bond connecting the Hieron of Epidaurus with the medicine of western Europe. Three centuries B.C. Rome was visited by dire pestilence. The rulers of Rome, having in vain sought to check it, sought the counsel of the Sybilline books, and were directed to bring Asklepios to Rome from Epidaurus. A galley was sent to the Saronic Gulf, and a mission visited the Hieron, bringing back to the ship one of the sacred serpents. The galley returned, entered the Tiber, approached Rome, and as it touched the insula in the Tiber the sacred serpent at once left the ship and found a refuge on the island. From that moment the plague is said to have rapidly disappeared. In gratitude to the god who was thus visibly among them in the serpent form, the south end of the island was modelled into the shape of part of a great galley of hewn stone. A temple of Æsculapius (as the Romans called him) was built adjacent to it, with portico and abaton. A well existing there became sacred to Æsculapius, and from that day to this the island in the Tiber has, through pagan and Christian times alike, been devoted to the cure and treatment of the sick. The prow of the stone galley still exists, with the effigy of the serpent and remains of the image of Æsculapius. The Church of St. Bartholomew stands on the site of the temple, and on or near the spot where stood the ancient abaton now stands a hospital served by the brotherhood of San Juan de Dios, the benevolent saint of Granada, where the sick folk of Rome are helped and tended; and there, unlike their predecessors of 2,200 years ago, if illness should terminate in death the poor weary souls are kindly and tenderly ministered to by priest, physician, and nurse until they sink into the last sleep.

It is doubtless in consequence of this episode of the founding of a temple of Æsculapius on the island of the Tiber that the staff and serpent of the Epidaurian god have been, and remain to this day the symbol of our profession.

SURGEON-MAJOR RONALD ROSS'S RECENT INVESTIGATIONS ON THE MOSQUITO-MALARIA THEORY.

By PATRICK MANSON, M.D., LL.D., F.R.C.P.,
Lecturer on Tropical Diseases, St. George's and Charing Cross Hospital Medical Schools; Medical Adviser to the Colonial Office; Visiting Physician of the Seamen's Hospital attached to the Branch Hospital, Albert Docks.

READERS of the BRITISH MEDICAL JOURNAL will recollect that in the issue of December 18th, 1897, Surgeon-Major Ronald Ross described certain pigmented cells found imbedded in the stomach wall in two specimens of a peculiar ("dapple-winged") species of mosquito which had fed on a malarial patient whose blood contained the crescent plasmodium. The characters of the pigment in these cells were such that Dr. Thin, Mr. Bland Sutton, and myself concurred with Ross in regarding it as the product of the malaria parasite; but as to whether it belonged to a living parasite, or whether it was simply malarial pigment taken up by certain gastric cells of the insect as a normal physiological operation, the preparations and other evidence before us did not, we concluded, warrant a positive statement.

In a second communication to the JOURNAL of February 26th, 1898, Ross stated that he had subsequently found similar pigmented cells in a third "dapple-winged" mosquito fed on crescent-containing blood; and, also, in a grey or "barred-back" mosquito which had fed on a patient with benign tertian infection. He further pointed out this significant fact—namely, that whereas the pigmented cells were but 7 μ in diameter in one of his mosquitos dissected two days after feeding, in another mosquito killed four days after feeding the pigmented cells measured 17 μ; in a third killed five days after feeding they measured 19 μ; and in one killed about a week after feeding they had a diameter of at least 25 μ. In other words, these cells exhibited one of the evidences of life-growth.

Prior to these observations Ross had examined hundreds of mosquitos both after feeding on malarial blood and also after feeding on healthy blood; but, although the dissections and microscopic examinations had been carefully conducted, hitherto he had not once encountered any structure at all resembling the pigmented cells in question. The explana-